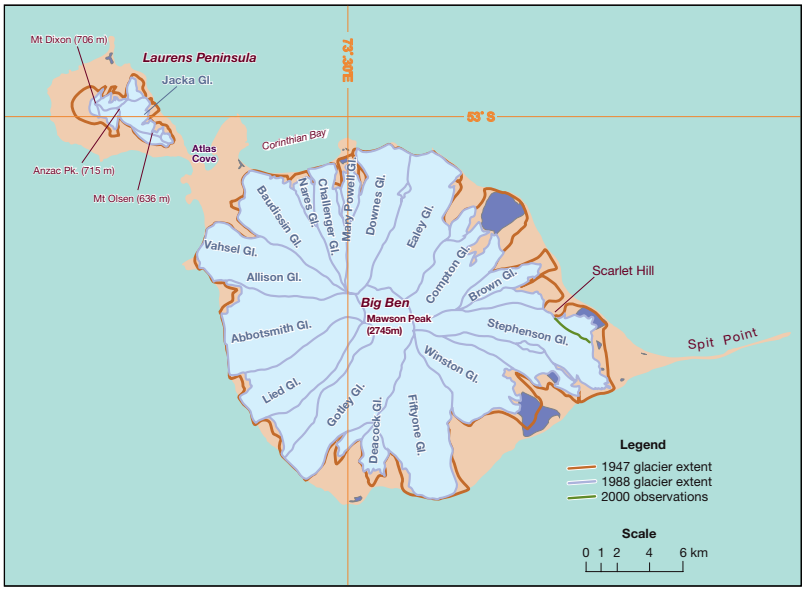
Our subantarctic glaciers: why are they retreating?

The glaciers of Heard Island – a 367 km^2 volcanic cone in the southern Indian Ocean – are in retreat. The question is, why? At what rate are they changing, and what is causing it? Why do the large glaciers on the windward southwest coast show little if any change? Unravelling influences such as climate change, volcanic activity and topography on the observed pattern of glacier behaviour on this infrequently visited island has been a challenge.

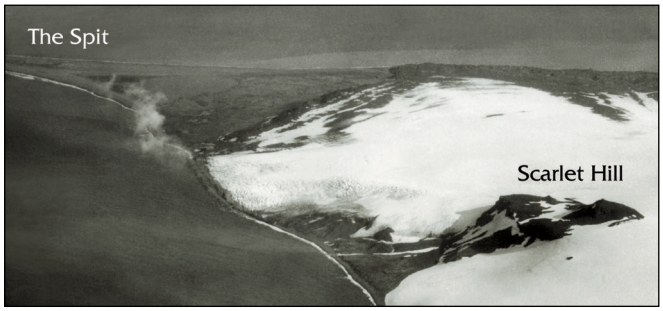
Maps, drawings and photographic images of Heard Island made since it was first visited in the early 1800s are a valuable record of glacial variation. Two Australian aerial photographic surveys – in December 1947 (resulting in the first attempt to produce a reliable map of the island) and 1980 – enabled comparison of many glaciers over this period by Allison and Keage (1986) and Budd (2000).



Andrew Ruddell

The extent of glaciers on Heard Island in 1988. The retreat since 1947 and the change in the Stephenson Glacier (1988–2000) is indicated.

The estimates of 1947 and 1980 glacier extent were based mainly on composite vertical and oblique aerial and marine photographic surveys. These produced reasonably accurate topographic detail for much of the island, but the western side and Laurens Peninsula were obscured by cloud during most visits. From 1987, geo-referenced satellite imagery and low level aerial photography enabled a much more accurate assessment of glacier surface extent, type and distribution.



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Andrew Ruddell

Above: The northeastern terminus of the Stephenson Glacier in December 1947. Below: The northeastern terminus of the Stephenson Glacier in October 2000. It has retreated 1.7 km from the coastline since 1947.

In 1947, Heard Island's glaciers covered 288 km2 or 79 percent of the island. By 1988 this had decreased by 11 percent to 257 km2. About half of this change occurred during the 1980s, when summer temperatures were about 1.7°C higher than the 1946-54 average. A Spring 2000 visit to the island found that the Stephenson (see photographs at left), Brown and Baudissin glaciers, among others, had retreated further.

At the end of the 1980s, a total of 29 glacier basins and 41 termini with a total estimated ice volume of about 14 km3 covered 70 percent of the island. The island's steep topography means that glaciers are relatively thin – about 55 m deep on average. The largest glacier, Gotley, originating on the island's highest point, Mawson Peak (2745 m) is 27 km^2 in area and 13.2 km long. Smaller glaciers such as Nares, Mary Powell, Brown, Deacock and those on the Laurens Peninsula have significantly receded, but the larger glaciers such as Gotley, Abbotsmith, Downes and Ealey show little or no change since 1947.

Most recorded volcanic activity appears to have been centered on Mawson Peak (see over, top left) and its southwest flank (see Quilty and Wheller, 2000), but this has had very little effect on the size of the glaciers on that flank, Gotley and Lied. Heat conducts slowly in snow and the melt water quickly becomes steam, resulting in a dampened response (Major and Newell, 1989). Thin deposits of volcanic ash will reduce albedo and accelerate melt, but thicker deposits of debris and cooled lava will

ROD LEDINGHAM

Lava flow down the southwest flank of Mawson Peak, onto the Gotley Glacier, January 1993. The Gotley Glacier has a large accumulation zone and is on the southwest coast. It loses about 80 percent of its ice through calving into the sea. Despite its proximity to volcanic activity it has not changed in size over the past 50 years.

remain on the snow or ice for many years, insulating it against solar radiation and thus reducing melt.

In simple terms, a glacier can be viewed as a large 'balance sheet' – what goes in as snow accumulation must go out through melt loss or calving of ice if it extends to the coast. If the water equivalent of what goes in is less than what goes out, then the glacier will be 'in the red' and it will recede back from the melt zone to a cooler, higher elevation where both components are 'balanced'.

Heard Island is cold and steep with a high snowfall. Many larger glaciers are unable to lose much ice in the narrow coastal melt zone. If this zone were wider some of these glaciers would be several kilometers longer, but instead the sea's action removes ice from glacier tongues. For such glaciers, up to 80 percent of their volume loss is through calving. Loss through melting is unlikely to be considerable even if conditions were significantly warmer.

The smaller, shorter glaciers are much more sensitive to temperature effects. Laurens Peninsula glaciers, whose maximum elevation is only 500 m above sea level, are particularly vulnerable. With a warming of 1°C the accumulation zone above the end-of-summer snowline elevation of about 300 m would recede to about 450 m elevation due to rain and increased melt. With an accumulation zone reduced to a range of only 50 m elevation, the glacier retreats until the elevation range of the melt zone is similar in size. This illustrates much of what has been happening for Laurens Peninsula glaciers since 1947, during which time their total area has decreased by over 30 percent. Jacka Glacier in the early 1950s had receded only slightly from its position in the late 1920s, but by 1997 it had receded about 700 m back from the coastline (see photographs at right).

The fluctuation pattern evident in the diversity of glaciers on Heard Island indicates a climatic cause rather than a change in volcanic activity.

Field studies on the Brown Glacier last spring have provided a better understanding of the physical characteristics and climatic dependence of this representative Heard Island glacier. Two months were spent measuring ice thickness, velocity, accumulation, surface elevation and past position. An automatic weather station was installed near the accumulation zone and has been providing some surprising information on the nature of relatively warm foehn winds.

Heard Island glaciers have a relatively small ice volume, so the contribution to sea-level rise through glacial melt is not a concern. However, the unique climate signal that is coming from this predominantly oceanic region is of vital importance. It indicates that the change observed elsewhere in Southern Hemisphere mid-latitudes – in New Zealand, Patagonia, Kergeulen Island, South Georgia and Bouvet Island – is widespread.

Andrew Ruddell, Glaciology Program, Antarctic CRC and AAD

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GRAHAME BUDD

The Jacka Glacier, Laurens Peninsula (29 January 1955). Taken from the summit of Mount Olsen.

L ROBERTSON

The Jacka Glacier in March 1997. It has retreated about 0.7 km since the early 1950s when it extended to the sea.